

**Applying ‘Learning-by-doing’ in
undergraduate project
management teaching via
Engineers Without Borders
Student Projects integration**



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OUTLINE

- Why Project Management (PM) is important in Engineering?
- Challenges in teaching PM to engineering students
- Course design to tackle the challenge - *Learning and enabling positive social impact: Integration of the Engineering for People Design Challenge*
- Results and discussions
- Conclusions

WHY PM IS IMPORTANT

- Project Management concepts and methods are generally applicable life skills




Source of the figure:
<http://abhinavpmp.com/2018/11/06/role-of-triple-constraints-in-an-agile-project/>

- Engineering companies survive on projects
- Consequences of problematic engineering solutions

CHALLENGES IN TEACHING PM TO ENGINEERING STUDENTS

- Project management is **Dry!!!**
- Concepts and methods are abstract and general
- Perceived as common sense

Project management (PMBOK® Guide) is  application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.



COURSE DESIGN TO TACKLE THE CHALLENGE

Initiative

Allow learners to **learn project management via doing a project**, i.e. **Learning-by-doing** (a teaching method for active learning) (Study.com., 2018) which

“presents real-life problems to the learners and then guide the learners to solve the problem by providing them with a hands-on activity to learn the solution”.

Challenges of doing this

- **Defining the appropriate scope of a project is difficult.**
- **Capacity issue (Usually only a few students can participate).**

COURSE DESIGN — Framework of teaching: Linking theory to practice

Lecture (200 students)



Theories, methods, project experiences

Project management context (e.g. what is a project?)

Scope management

Quality management

Schedule management

Cost management

Risk management

⋮

Seminar (≈30-35 students each, i.e. 6 groups)



Group project practice

Learn the project background and team up

Identify project scope

Evaluate design solutions

Schedule plan

Estimate design costs

Risk analysis

⋮

Placement opportunities

Industry visit

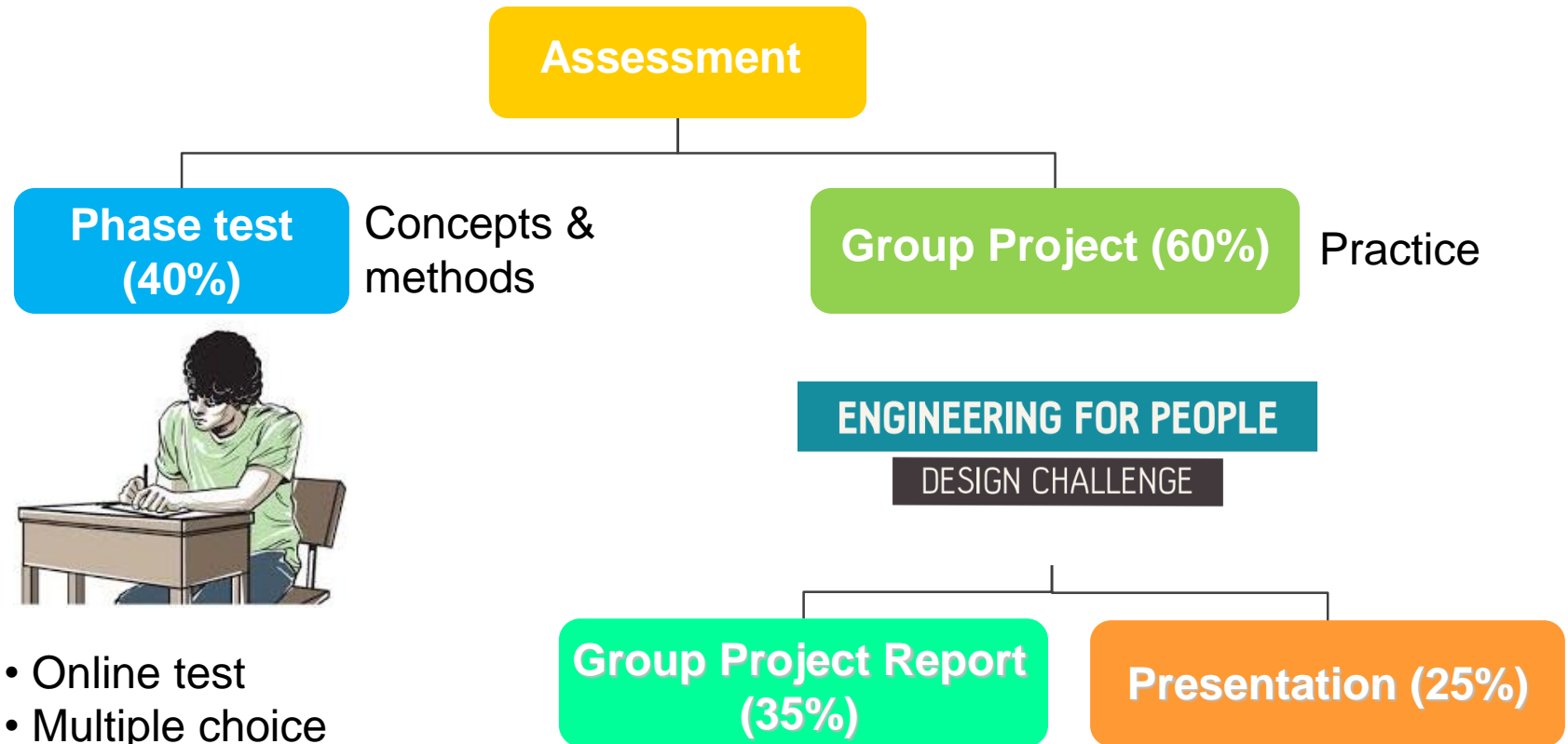
Guest lectures from experts & students

Design and management reports

Project management knowledge

Techniques and soft skills for future development

COURSEWORK ASSESSMENT



- Online test
- Multiple choice questions (30%)
- Open questions (30%)
- Exercises (40%)

COURSE DESIGN — Group project selection



- **A group project**
(4-5 students in each group)
- **A real-world case study**
(2019-20: Makers Valley, South Africa
2018-19: Tamil Nadu, India)
- **Multiple design areas and open questions to choose**
- **Main deliverables**
Design solution &
Project management report
- **Duration**
Throughout the whole module
- **My role**
Lecture and seminar design
Project tutor

Source:
<https://www.ewb-uk.org/engineering-for-people/>

LEARN

ENGINEERING FOR PEOPLE DESIGN CHALLENGE

Embedding global responsibility into engineering education and inspiring the engineers of the future.



UK

ENGINEERS

WITHOUT BORDERS

- Provides opportunities for students to design creative solutions to real world problems through real, sustainable and cross-cultural development projects
- Provides a practical, team-based and innovative approach to assessment inspiring our students to become better engineers and responsible global citizens
- Embedded in the Y2 Project Management module (ENGD2010) for ALL Engineering courses

ENGINEERING FOR PEOPLE DESIGN CHALLENGE

2020/21 DESIGN AREAS (LOBITOS, PERU)



 ENERGY



 BUILT ENVIRONMENT



 TRANSPORT



 DIGITAL



 WATER



 SANITATION



 FOOD



 WASTE

Engineering for People Design Challenge

 ENERGY



 BUILT ENVIRONMENT

 SANITATION

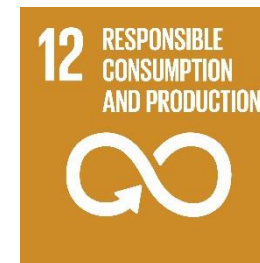


 TRANSPORT

 WATER

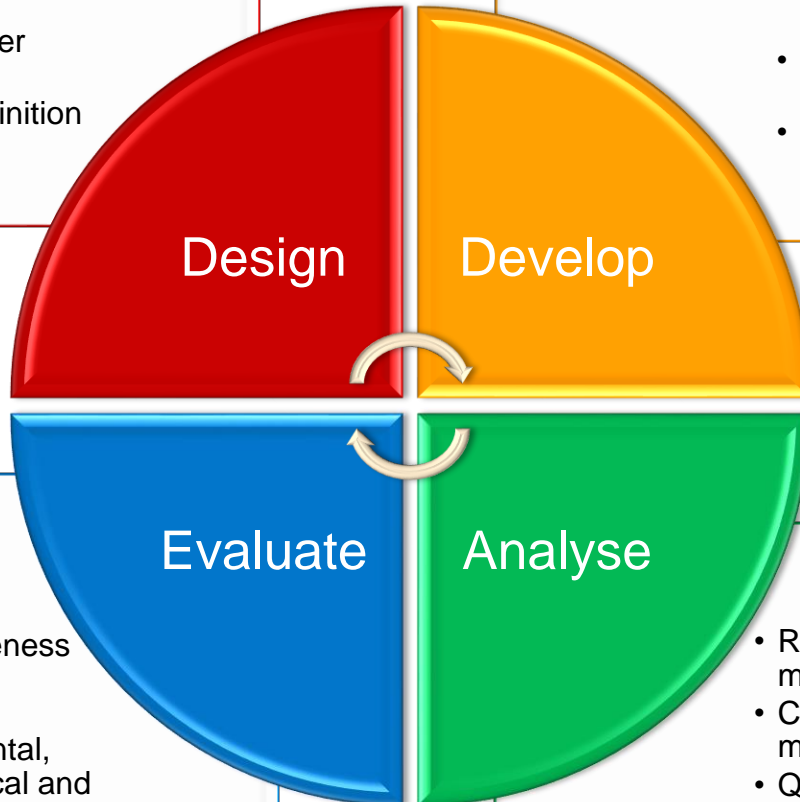
 DIGITAL

 FOOD



 WASTE

ENGINEERING FOR PEOPLE DESIGN CHALLENGE



- Understand the context
- Stakeholder analysis
- Scope definition

- Planning (schedule and resources)
- Research design options
- Select the best design solution

Design

Develop

Evaluate

Analyse

- Appropriateness to the local community
- Environmental, social, ethical and economic impacts

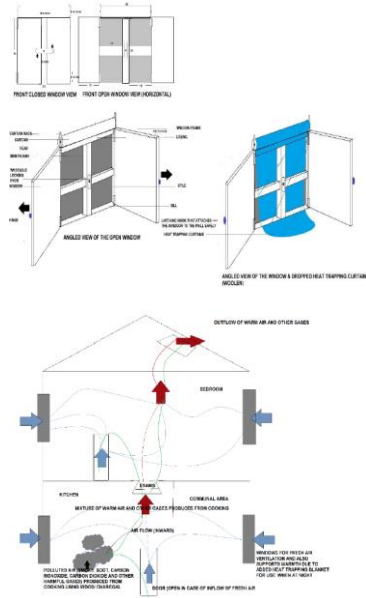
- Risk management
- Cost management
- Quality management

- Problem-based learning
- Using a user-centred design approach
- Evaluate the consequences of design decisions at the local and global level
- Develop their engineering skills
- Develop transferable skills:
 - Teamwork
 - Problem-solving
 - Communication
 - Collaboration
 - Planning and project management

ENGINEERING FOR PEOPLE DESIGN CHALLENGE DMU DESIGN SOLUTIONS



2014/15 (Sandikhola, Nepal)
Two-latched window



2015/16 (Bambui, Cameroon)
Early warning system

DMU PROJECT: Early Warning System: The Alarm Beem

I. Abstract
Operation Beem (OB) has been developed as a solution to assist children, especially in rural areas, from the common and deadly danger of malaria. The system consists of a simple alarm system that is easy to use and can be made by the community.

II. Aims and Objective
The system is designed to be a simple and easy-to-use alarm system that can be made by the community.

III. Economic Factors
The system is designed to be a simple and easy-to-use alarm system that can be made by the community.

IV. Environmental Factors
The system is designed to be a simple and easy-to-use alarm system that can be made by the community.

V. Social Factors
The system is designed to be a simple and easy-to-use alarm system that can be made by the community.

VI. Risk Assessment

VII. Cost

Item	Quantity	Unit of measure	Local Price (KSh)	Unit Cost (KSh)
...

2016/17 (Lobitos, Peru)
Rebuild

Rebuild

Key Design Objectives

- Improvement in waste management and housing
- Recycling of plastic in a strong, waterproof, recyclable structure
- Weather resistant, material will not degrade under harsh conditions
- Can resist high temperatures, safety factor of over 5
- Estimated cost: \$300 per device

Environmental Benefits: Greater motivation for efficient waste management. Plastic is being recycled and re-used in a positive way.

Social Benefits: Its waste is separated and gathered, the dumps will improve easily.

Economic Benefits: Cheap materials housing. Green bricks can be used to nearby districts and villages. New jobs created at the dumps for local residents.

2017/18 (Kibera, Kenya)
Solar powered street lighting

SOLAR POWERED STREET LIGHTING

GROUP 5 TEAM MEMBERS: Daniel Gebore, Jacob Waino, Jennis Thomas, Edward Sky, Luke Siree

AIMS & OBJECTIVES

- Reduce crime by 20% in Kibera, LA slum.
- Reduce power consumption by 50%.
- Reduce the current 50% consumption rate.

PROTECTION

- RHINO ARMOUR
- HIDDEN WIRE
- CONTROL PANEL
- BASE
- WHEELS

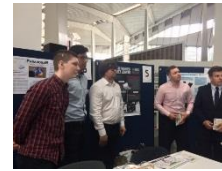
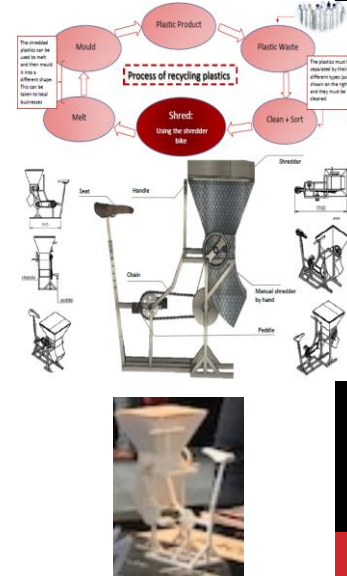
SOLUTION

- Using green LED lighting, charged by three photovoltaic cells, power can be stored to provide the power for up to 12 hours.
- The use of solar energy for street lighting will result in reduced power and fuel consumption.
- Provision of solar energy will allow the residents to access lighting at night and during the day.
- Use of solar energy will reduce the environmental impact.
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CONCLUSIONS

- The use of solar energy for street lighting will reduce power and fuel consumption.
- Provision of solar energy will allow the residents to access lighting at night and during the day.
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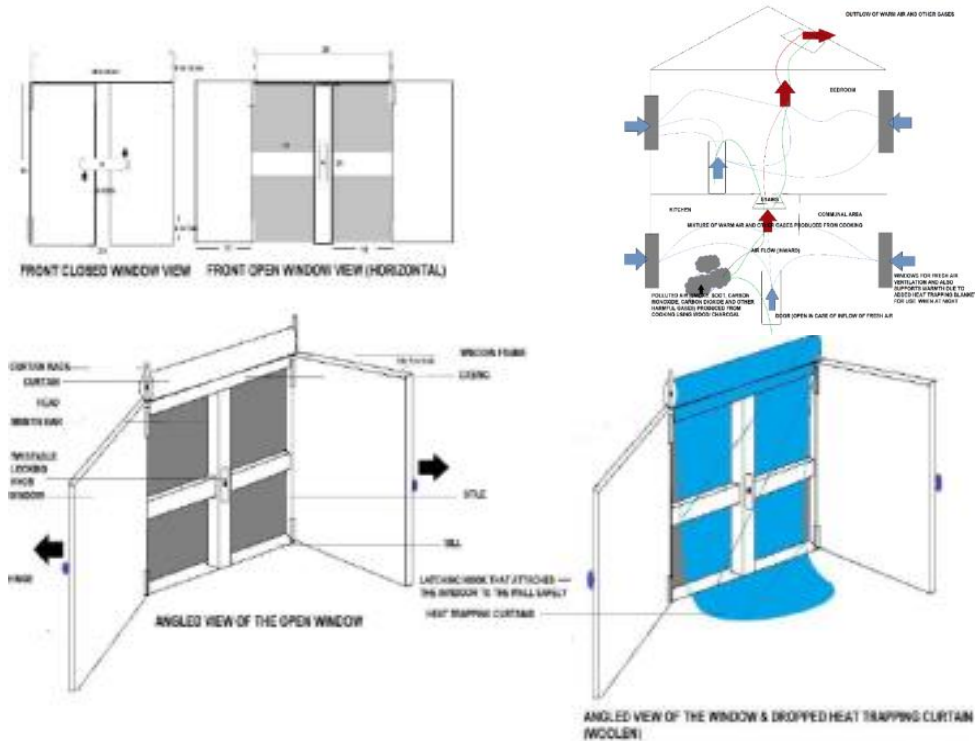
2018/19 (Tamil Nadu, India)
Shredder bike



ENGINEERING FOR PEOPLE DESIGN CHALLENGE

DMU DESIGN SOLUTIONS

2014-2015: Two-latched window (Sandikhola, Nepal)



*“... it was nice to have this module **linked to a real project**... Being able to apply yourself as an engineer to any project is important, and **designing creative solutions** that really could **make a difference in somebody’s life** is very rewarding and exciting.”*

Henry Spencer (2014/15)

COURSE DESIGN — Implementation

Lecture (200 students)



Theories, methods,
project experiences

Project management context
(e.g. what is a project?)

Scope management

Quality management

Schedule management

Cost management

Risk management



Define Project Aim

One or two sentences that specifies **WHAT** the project is trying **to achieve (not what to do)**.

- The main problem that the project will solve
- The main negative effects that the project will minimise or eliminate
- The main outcome at the end of the project

Define Project Objectives

Few concise bullets points that specify **HOW** the aim of the project **will be achieved**.

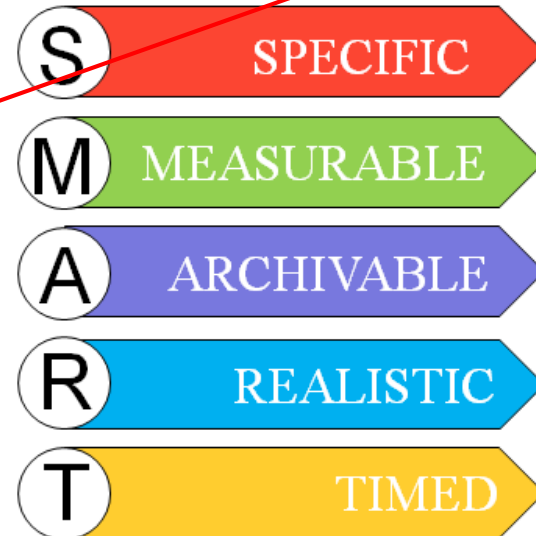
- What factors or negative causes can be addressed by the project?
- How can these factors be addressed?
- To what extent?

What makes a good objective?

EXAMPLES

An objective	An Smarter Objective
Improve awareness of energy and water conservation issues	Educate 1,000 households within Blacktown Council on ways to reduce energy and water usage by 10%

Part of the success criteria



TEMPLATES

ENGD2010 – Project Management (2018-19)

Seminars – week 19

Project scope - 1

Group Project overview

Group Project title (or at least selected design option)	
Group Project authors (team members)	

Project aim [specifies WHAT the project is trying to achieve (not what to do)].

- What problem is the project addressing?
- What is the broader impact that the project will contribute to?
- Why is it important to the local community where the project is taking place?
- How does it fit with the local initiatives and targets?

Project aim (1-3 sentences)	
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Project objectives [HOW the aim of the project will be achieved]

- What results/outcomes are anticipated from this project?
- How will the objectives contribute to addressing the identified problem?
- What improvement is targeted? How much improvement is required?
- Are there anticipated savings for the project?

Project objectives (3 to 5 bullet points)	
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Product Design Requirements

Think about some generic design requirements (first column) that the proposed group design solution may require (regardless of the technology). Complete the table for those requirements applicable to your selected design option.

Design requirements	Brief description of the requirement	Value (success criteria) [units]	Comment
Performance (efficiency or expected output)			
Special features of functionalities			
Capacity (size and weight)			
Operation and maintenance			
Materials OR manufacturing			
Product cost viability			
Other (please specify)			

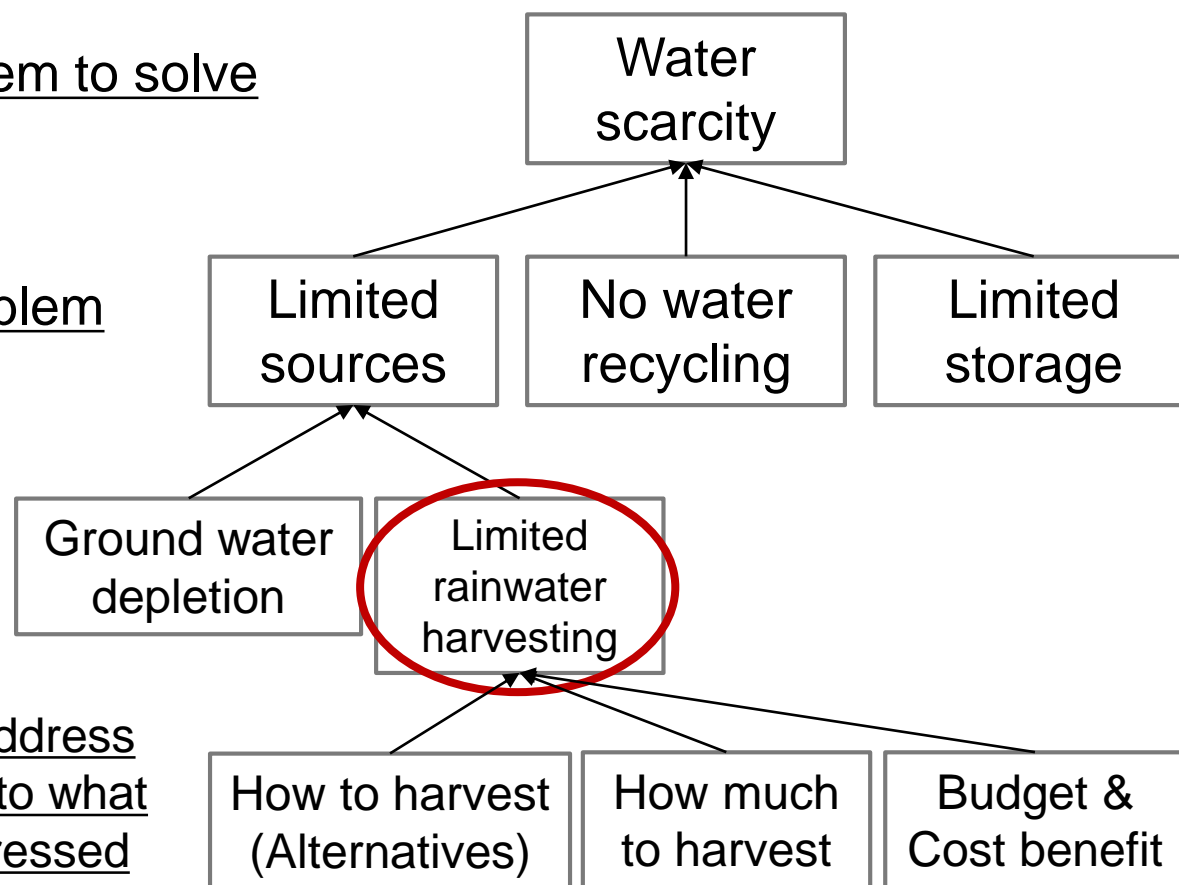
HOW TO DEVELOP YOUR OBJECTIVES?

You may want to identify:

- The specific problem to solve

- Causes to the problem

- Which cause(s) to address & how to address & to what extent it can be addressed



COURSE DESIGN — Implementation

Lecture (200 students)



Theories, methods, project experiences

Project management context (e.g. what is a project?)

Scope management

Quality management

Schedule management

Cost management

Risk management



LIFECYCLE COSTING

- Life cycle costing, or whole-life costing, is the process of estimating how much money you will spend on an asset over the course of its useful life. ("cradle to grave" or "womb to tomb")
- Capital expenditure (CAPEX)
- Operating expenditure (OPEX)

Theory

The screenshot shows a BBC News Magazine article. The main headline is "How does a company cost £1?". Below the headline, it asks "WHO, WHAT, WHY? The Magazine answers...". The article text discusses a struggling furniture firm MFI, once worth £1bn, now reported to be in take-over talks which could see the company sold for £1. It mentions that if this suggests that the company's prospects are now flatter than flat-pack, it's still only part of the story. At the bottom, it says "As well as this token price tag, the take-over by a private equity firm could also involve the seller stumping up for a multi-million pound "dowry" as an added incentive." A gold coin is shown with the text "Symbolic proof of the exchange".

Real life examples

The screenshot shows a news article titled "The German prince Ernest of Hannover sold his castle for 1 dollar". Below the title is a photograph of a large, ornate castle with multiple towers and spires.

"I could no longer take care of the expenses," the prince admitted. The maintenance of the castle, of 135 rooms, was exterminating his personal wealth.

Discounted Cash Flow and Net Present Value

Investment: £10,000

Rate: 8%

Net **Methodology**

Year	Cash flow	PV (A)	PV (A)	Year	PV (B)	PV (C)
0	-£10,000	-£10,000/(1+0.08) ⁰ =	-£10,000	0	-£10,000	-£10,000
1	£2,000	£2,000/(1+0.08) ¹ =	£1,852	1	£9,259	£5,556
2	£4,000	£4,000/(1+0.08) ² =	£3,429	2	£2,572	£3,429
3	£12,000	£12,000/(1+0.08) ³ =	£9,529	3	£2,381	£3,969
NPV = Σ (PV) =			£4,809	NPV	£4,213	£2,954

PROBLEM SOLVING AND KNOW STANDARD OF GOOD WORK

Example:

In Kenya, availability of shoes is low due to lack of resources. What is your solution?

Step 1. Study on the context (PESTLE)



- What kind of shoes people there are looking for and why?
- Why it is a problem for local people?
- What are the common ways to get shoes and why it is currently not working in Kenya?

PROBLEM SOLVING AND KNOW STANDARD OF GOOD WORK

Step 2. Define the problem and the design criteria

- What is the key cause(s) of the problem?
- The specific criteria of the shoes demanded. E.g. The acceptable price, material, functions? The local standards. (Design requirements)

THE PROCESS OF IDENTIFYING GOOD DESIGN SOLUTIONS

Step 3. Explore all available solutions

Please note:

- Need to do literature review rather than only brainstorming.
- If a method is good but too expensive, it is not a real solution.
- Need to adapt it into the local conditions, e.g....

An example of scaffolding



PROBLEM SOLVING AND KNOW STANDARD OF GOOD WORK

Step 4. Justify your recommendation and explain how it works

Please note:

The idea and efficiency should be self-explanatory.

If you need many words to explain, it is likely not a convincing solution.

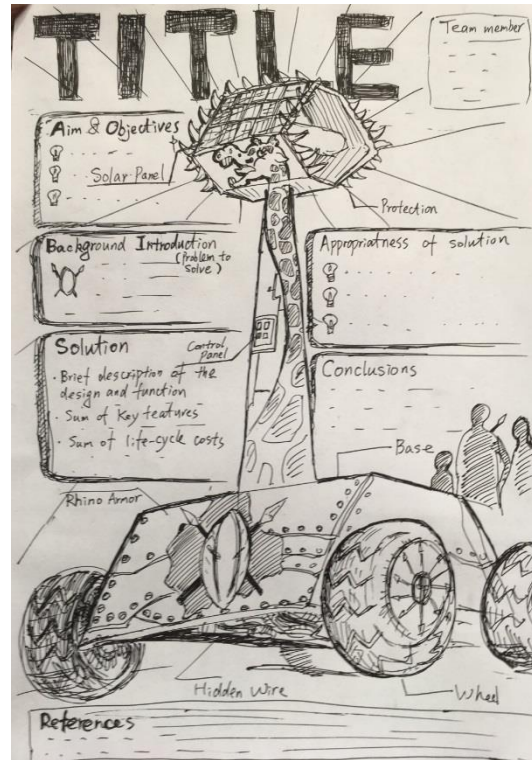
PROBLEM SOLVING AND KNOW STANDARD OF GOOD WORK

The current solution to the example's problem



<https://m.youtube.com/watch?v=z8eY-LR494U>

Lecturers' sample design



Learners' final design

SOLAR POWERED STREET LIGHTING

GROUP 5 TEAM MEMBERS

AIMS & OBJECTIVES

- Reduce crime by 30% in Kibera, UK studies show reduction in crime due to implemented street lighting.
- Upsurge investment in the villages of Kibera as a result of reduction in crime.
- Decrease the current 50% unemployment rate.

PROBLEMS TO SOLVE

- The current floodlights in Kibera are not powerful enough to light vast areas. (2)
- Over 40% of residents illegally access electricity to power lighting, reduction in illegal tampering would increase the amount of disposable income to the local community.
- Illegal token machines currently used to reduce cost of electricity are deemed to be unsafe for homeowners.

SOLUTION

- Using glare free LED lighting charged by three photovoltaic cells, there will be enough lighting provided to cover an area of 11000sqm.
- The use of solar panels to collect energy will result in increased longevity and will help reduce household lighting expenses.
- Portable design will allow the residents to access lighting in expanding areas in Kibera through manoeuvring the portable street light into appropriate places.
- Rough terrain anti theft wheels and protective barbed wire will help prevent theft of the lighting unit.
- Telescopically designed so multiple raised heights can be achieved to accommodate vast building sizes.

APPROPRIATENESS OF DESIGN TO THE LOCAL COMMUNITY

- A UK study suggests that implementing street lighting is proven to reduce crime by up to 30% in 12 months. A reduction in crime would benefit Kibera massively. It would improve the quality of life for local residents and may result in future private investment if seen as a labor area to reside.
 - Maintenance of the Portable Street Lighting, a responsibility which could be contracted out to local inhabitants. This would generate skilled job opportunities for the community.
 - As it is an off-grid system, this will increase reliability and will ensure the safety of the local community.
 - The wheeled design eliminates the need for heavy machinery during the installation and maintenance stages. The roads in Kibera are not adequate for large transportation and equipment to pass through.

CONCLUSIONS

- The use of the Solar Powered Street Lighting will reduce crime in Kibera by up to 30% within 12 months.
- Job opportunities will be created as a result of the maintenance and manufacture of the proposed design.
- Overall safety of the community will be enhanced due to modern technologies and a reduction in illegal tampering.

REFERENCES

[1] [https://www.researchgate.net/publication/318614146/figure/fig/1/figure-fig1/1516711111111/1516711111111/1516711111111.png](#) (Accessed 10/04/2018)

[2] [https://www.researchgate.net/publication/317701710/figure/fig/1/figure-fig1/1516711111111/1516711111111/1516711111111.png](#) (Accessed 10/04/2018)

[3] [https://www.researchgate.net/publication/317701710/figure/fig/1/figure-fig1/1516711111111/1516711111111/1516711111111.png](#) (Accessed 10/04/2018)

Learners' original design

PORTABLE SOLAR POWERED STREET LIGHTING

GENERATING LIGHT TO PROVIDE A SAFER, MORE ACCESSIBLE KIBERA.

-OUR AIM IS TO REDUCE CRIME IN KIBERA BY 30% IN 12 MONTHS.

-WE BELIEVE IMPROVING THE LIGHTING IN KIBERA WILL ATTRACT FUTURE INVESTMENT, INCREASING EMPLOYMENT OPPORTUNITIES FOR THE LOCAL PEOPLE.

FINANCED BY THE KENYAN GOVERNMENT

REDUCTION IN UNEMPLOYMENT

REDUCTION IN CRIME

INCREASES INCENTIVE FOR PRIVATE INVESTMENT

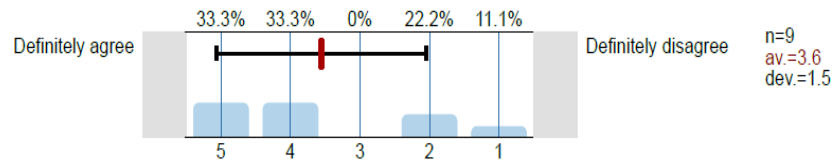
- ROUGH TERRAIN WHEELS WITH ANTI-THEFT LOCKING SYSTEM
- GLARE FREE LED CREE LIGHTING
- PHOTOVOLTAIC CELLS PRODUCING LONG TERM EFFICIENCIES OF UP TO 20%
- PORTABLE DESIGN TO HELP PROVIDE LIGHT IN AREAS MOST NEEDED

RESULTS

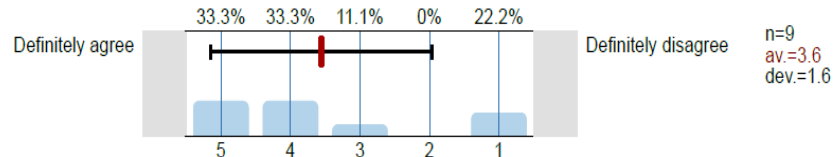
The 2019/20 module survey result shows a score of 3.8/5, which is the average of 23 evaluations (range from 3.3 to 4.6) categorized into seven categories

2. Learning Outcomes

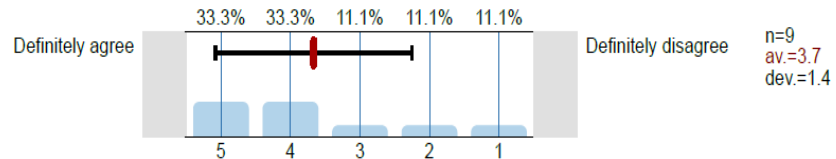
2.1) The module was academically stimulating.



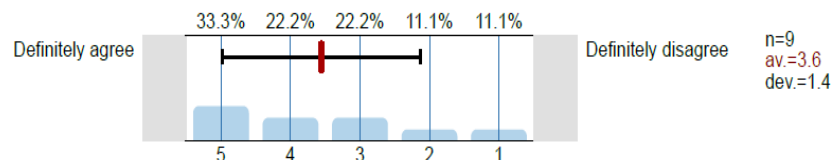
2.2) The module provided me with opportunities to apply my learning and do my best work.



2.3) It was clear why I should attend and contribute to classes / seminars / lectures / labs / practicals.



2.4) I felt engaged with the content and aims of the module.

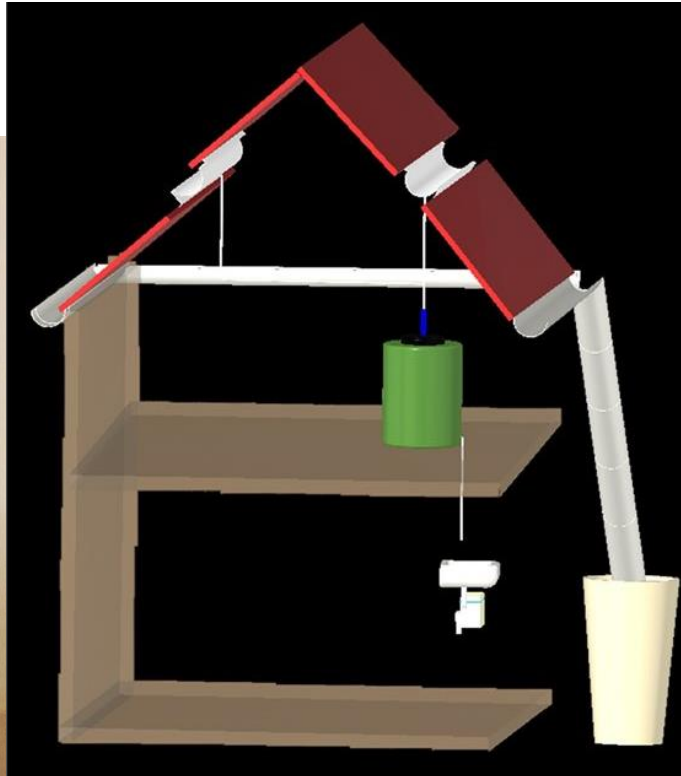


One recent outcome: 'Engineering students secure top prize out of UK universities for sustainable water system design

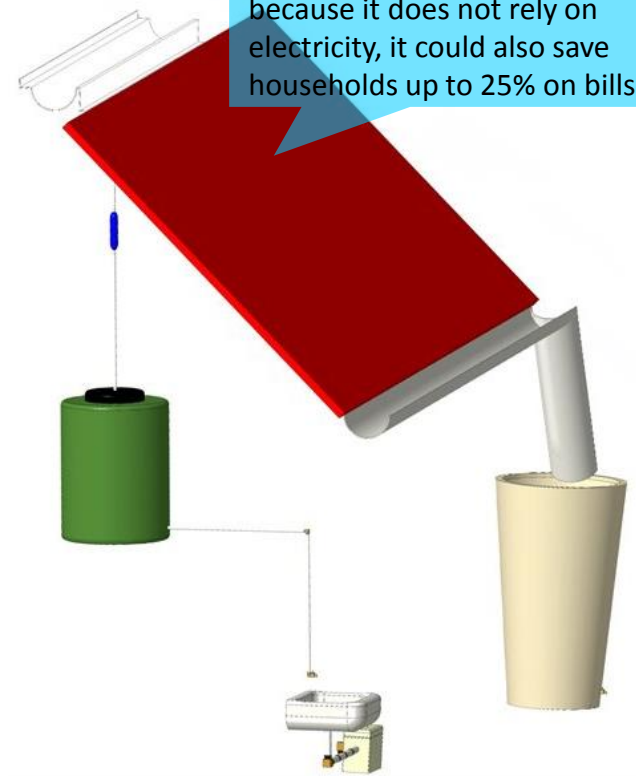
<https://www.dmu.ac.uk/about-dmu/news/2020/july/engineering-students-secure-top-prize-out-of-uk-universities-for-sustainable-water-system-design.aspx>



Pawel Szczygiel was the team leader on the project



Engineering students designed a sustainable water gathering system



The system would reduce tap water use by 40 litres a day and because it does not rely on electricity, it could also save households up to 25% on bills.

The system reuses rainwater by collecting it through two gutters

CONCLUSIONS

- The developed **Project-based Action Learning (PAL)** framework engaged learners and created mutual benefits in terms of developing theoretical understanding and practical problem-solving ability.
- Applying the award-winning Engineering for People Design Challenge project motivated learners to deliver high quality work, e.g. one group is awarded the runners up prize in the E4PD Grand Final 2020.
- The project also raises the awareness of UN SDG goals in sustainable engineering, and presented connections between engineering and people and how the solutions link to society, e.g. technology serving people to improve their lives.

**THANKS VERY MUCH
FOR YOUR ATTENTION**

